The Adoption of Big Data Concepts for Sustainable Practices Implementation in the Construction Industry

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Abstract

The global construction business is on a point of a paradigm shift. The exponential growth of digital technologies, the increasing impacts of climate change, impending Brexit and looming social and environmental pressures are driving change to the construction industry. Increasingly policies press for the adoption of sustainability and construction organisations are realising that small sustainable impacts are no longer enough. Therefore, measurement is one of the keys to the implementation of sustainable construction strategies. Advances in data gathering, computing power and connectivity mean that construction organisations have more information and data than ever before. Collecting, analysing and understanding those large volumes of available data, known as Big Data, about how an organisation operates sustainably leads to knowledge that can improve decision making, refine goals and focus efforts. However, when it comes to sustainability the great thing about big data is that it is unlocking the ability of businesses to understand and act on what is typically their biggest sustainable (i.e. economic, social and environmental) impacts – the ones outside their control. Measuring and understanding how doing business really does affect the natural world will open new opportunities for bringing sustainability inside an organisation: creating change, cutting costs and boosting long-term profitability in a resource-constrained world. Still, there are issues and challenges around gathering sustainability-related data, as well as in analysing and interpreting of data points. Therefore, the aim of this research is to explore the barriers to adopting big data related to sustainable strategies.

The relationship between Policy Making, Big Data and sustainability is still in early stages, but already several applications can be mention to the environment, health and construction, such as biodiversity loss monitoring, pollution zones Identification, endangered species location, smart energy management, cost reduction or investment assessment. In the same way, barriers and opportunities were identified, for instance: the lack of financial resources and business case, skills and training, unequal opportunity and security and disclosure issues among the barriers, and partnership, emerging and accessible technology, personalization of the environment among the opportunities. Finally, the biggest challenge presented by the implementation of Big Data is concept standardization, since there are many areas in which one way or another is making use of this technology without being recognized as such. In the same way, the greatest asset that represents the use of Big Data for sustainability is the identification of the future causes and consequences of climate change and its subsequent prevention or mitigation in time.

Key Words: Barriers, Big Data, Construction, Environment, Policies, Sustainability

I. *INTRODUCTION*

The unstoppable worldwide technological development has influenced almost all areas of human life, from the development of new medical techniques to mobile devices that allow instant access to billions of databases, placing large amounts of knowledge within the reach of billions. At the same time, this software and devices have the ability to capture information from its users and the surrounding environment.

For years, this information generated by the devices that surround us every day has been collected, stored and analysed with different purposes such as commercial use like the identification of factors that allow prediction of user consumption and the optimization of resources utilization such as energy. The volumes of data captured grows exponentially every second so conventional analysis tools have become obsolete. For these situations, a solution known as Big Data (BD) has emerged and its application can be found in almost all areas of human development.

The implementation of policies by governments that allow complete adoption of sustainability and the fulfilment of the Millennium Development Goals (MDG) in the case of developing countries and Sustainable Development Goals (SDG) for the European Union (EU) and other developed countries has occupied the number one position of governments agenda. The use of new tools and new technologies play a major role in the implementation of new policies regardless of the area, the use of big data could allow the measurement of policy impact and retrofit them to adjust and adapt as per requirements and to improve decision making.

Another example of the possible use of BD is the construction industry and its sustainable approach, where the production data is meet through new design methods such as BIM and other tools that generate large volumes of digital data containing the specifications and characteristics of the projects, as well as the use of smart devices in new projects and existing buildings that generate data in real time of the internal operation of the buildings as well as the people who use them.

The analysis of this data is what opens the way to the efficiency of resources from the design stages to the end of the useful life of the construction projects, as well as the reduction and management of waste throughout this period, which is the main objective of sustainability and whose precepts can also be applied to the operational management stage of existing buildings.

The method used to carry out this research has been a review and analysis of the latest Big Data publications with

the aim of identifying concepts, relationships with the areas of policies, construction and sustainability, as well as the identification of possible applications, barriers, challenges and opportunities represented by the implementation of this concept in the industry.

II. BIG DATA

Technological development advances at an unprecedented pace, every day there are devices that seek to improve the quality of life starting from the most basic tasks such as cleaning the home or accessing information to the less trivial, such as efficiency of the medical equipment or reduction of emissions and waste.

What is a common factor of technological development being the exponential increase in data production, thanks to features such as mobile devices, and smart devices that are in the hands of users generating and transmitting information at all times, the analysis of these data allows to determine innumerable characteristics of both of the users that produce them and the surrounding environment.

A. Big Data Definition

Many authors describe Big Data as an activity carried out on a large scale to extract or create "new forms of value" [1], [2] and [3], but this definition corresponds more technically to Big Data analysis, since only by analysing the data it is possible to determine any type of value present in it. Instead [1] also provides a clearer explanation of the subject by describing BD as a dataset or database whose volume exceeds the capacity of traditional tools for their management in terms of capture, storage and analysis. In the same way something that most authors agree on is that to be considered as such this database must comply with certain characteristics such as volume, variety and speed, better known as the 3V's of BD, Volume refers to the amount of space that the data set occupies, velocity refers to the speed with which the data is produced and transmitted and finally variety refers to the diversity of ways in which this data can be presented [1], [2], [3] and [4].

Another aspect in which many authors agree is the benefits of BD analysis that vary from the prediction of relationships, trends and possible future events to improve decision making, to the acquisition of knowledge for subsequent capitalization, tools that adds value to the market that seeks to determine possible targets for the products that are offered and that in the same way allows to adapt the products and services offered to the needs of the consumers.

B. Big Data Classification

It was previously mentioned that the definition of BD is often confused with the BD Analysis definition, and this happens because the concept of big data is often identified as something abstract rather than something tangible and specific, so it is good to emphasize that Big Data is the database which according to [4] is formed by two aspects that complement each other: Big Data Engineering (BDE) and Big Data Analytics (BDA).

BDE is the part of Big Data that is responsible for providing support for data processing activities as well as the capacity to store it, in other words, "the BDE provides the infrastructure to perform the BDA" [4]. In the same way, BDA is the process by which the output is extracted as knowledge or pattern determination to improve decision making, in many cases BDA includes common processes for data analysis but on a larger scale.

III. POLICY DRIVE

Governments have been driving the adoption of sustainability for approximately six decades and what has changed in that period of time is the policies and its process. From the acknowledgement of the need for the adoption of sustainability to the data collection and assessment of the impacts produced by those policies.

Policies are the way of governments establish its actions and decisions, according to [6], the policies can appear in several forms such as regulations, money spending, tax management, services or information, but all with the objective that its consequences should be positive to the "public good". The of achieving a goal or objectives is through the implementation of policies they allow to predict and address problems that affect society and enhance the government development since they can be implemented at several levels of the governmental structure. Policies create change whiting an organization whether they will be positive or negative will depend on the point of view of those affected by it and the objectives to be achieved [7].

The process of policy-making used to this day involves a series of stages generating a cycle (Fig. 1) that should be maintained in order to update and sustain the validity of the policy. Based in a data analysis process that begins with the citizens as both knowledge and data gathering source, policy makers and other stakeholders are also involved in the process that goes through data validation e interpretation to the actual policy development and posterior dissemination and impact monitoring which reaches back to the primary source of knowledge [8].

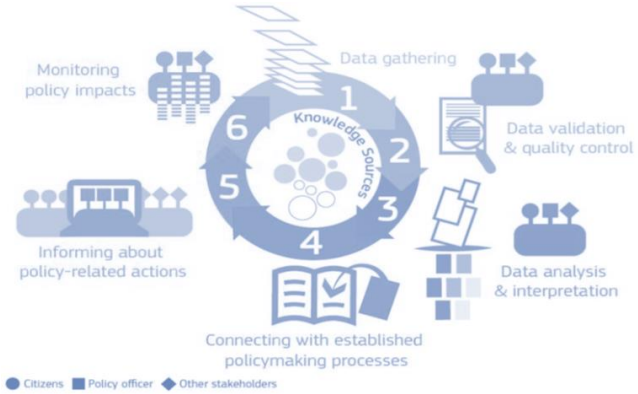

Fig. 1 Process Used Nowadays for Policy Making

The use of BD for policy making will be determinant in the years to come. It will enable the development of "E-Government Services" enhancing the interaction between the government and the society, improve transparency and provide real-time solutions to emerging problems [9]. In the same way represent a complete redesign of the policy-making process mentioned above, presenting core cycle changes such as the substitution of all the data related stages with BD Analysis processes, as well as replacement of the impacts monitoring stage with highly predictive tools provided by BD.

The implementation of policies whose objectives are the adoption of sustainability cover different areas and activities, both economic and social including the construction industry which has proven to be a great challenge due to the nature of the activity in terms of resource consumption and overall environment modification.

IV. BIG DATA AND CONSTRUCTION INDUSTRY

According to [10] in 2016 the Construction Industry alone contributed to the 6.1% of UK's Gross domestic product (GDP), In the same way this sector is characterized by keeping up with the technological developments, proof of this is the adoption of "Building Information Modelling" Process (BIM), which is a tool that allows the unified representation of the different aspects of a construction design, in a generalized way [11] .highlighting that by the time the BIM mandate was promulgated in 2016 by the Government [12], this tool was already being used by a large part of the industry. There has also been an exponential increase in the use of smart devices within the projects in order to make some activities within the construction field more efficient.

In the same way, this sector has been implementing for decades a sustainable approach whose importance rests on the fact that the construction activity is one of the main consumers of natural resources, so it is necessary to develop the ability to carry out any activity respecting the ability of the planet to provide the raw material for them, which represents the basis of sustainability.

According to the above, it is logical that both the construction sector in general and the sustainable trends within it could benefit greatly from the adoption of BD, harnessing the insight and value extraction characteristics of BD to create new and more efficient ways of adopting sustainability in the industry.

A. Relationship Between Big Data, Sustainability and Construction

The relationship between big data and construction lies in the amount of digital information that nowadays is been storage, in construction projects this data comes in every form available form pictures and videos to projects descriptions in word documents, blueprints, Computer-aided Designs (CAD) or documents and overall BIM, all this information grows bigger every day requiring new tools for its analysis.

The use of BD to analyse this information and extract knowledge that allows or enhance the adoption of sustainable practices in construction becomes more important every day, authors like [1] indicate that many organizations are already including Big Data in their efforts to achieve sustainability.

BD Also creates a link between the Construction and the Government by retrofitting and analysing the impacts of the policies that promote the adoption of the sustainable practices in the industry allowing at the same time the adjustment of those policies to ensure a better performance and an efficient achievement of the goals.

B. Big Data Applications in Sustainable Construction

The number of applications for the insights obtained through big data analysis is countless and applicable to several activities, from diseases prediction to identifying the reason behind the poor performance when implementing certain practices to resources administration to mention a few.

The applications of big data in the construction industry could become a widespread practice since nowadays it allows to assess performance, reduce waste, improve energy efficiency, resources administration and overall the enabling of innovation. All of the above translates directly or indirectly into economic benefits, social gain and environment preservation.

Table 1 Big Data and its Relationship with the Construction Industry

Applications	Barriers	Challenges	Opportunities
Energy Efficiency	Data Reliability	Concept Standardization	Partnerships
Waste Prediction Minimization	Bureaucracy	Lack of Skills and training	Environment Personalisation
Carbon Emissions Reduction	Creation of a New Market with Unequal Opportunities	Confidentiality, Security and Disclosure	Emerging and Accessible Technologies Availability
Improvement of Decision Making	Failure to Stablish a Bussines Case	Lack of Economic Support	Emerging Sources of Funding
Risk Assessment Optimization	Lack of Interest and Knowledge for its Implementation	Lack of Government Regulation	New Areas of Specialization for Professionals

Subsequently, many other aspects arise from the application of BD such as Barriers, Challenges and Opportunities, In the table presented above (Table 1) the most important ones are listed. Even in a case where all the main application listed can be categorized as positives the main obstacle to overcome is the resistance to change of an industry that has more than a hundred-year applying the same practices and that its main focus is profit, but at the same time, thanks to government policies that have been driven to the adoption of new methods and technologies to adjust its activities with today's requirements towards sustainable practices and the full adoption of sustainability.

The predominant aspect that to this day slows the development of BD and its applications is the security topic, more than any of the barriers or challenges listed before the fact that the data that is intended to be analysed belong to people who may or may not be aware of the information that they are sharing or in some case whether or not they gave the permission for this information to be used for other means that the ones they have agreed to.

V. CONCLUSION

Policies are tools that produce change, and the policies and the goals they aim to achieve benefit greatly from technological advances such as Big Data. The increasingly amount of available digital information urges the development of tools to add and extract value from this data benefiting several areas of human development.

Some activities tend to invest and profit from new technologies sooner than others such is the case of the health industry who is already creating profit from the use of BD to predict diseases outbreaks and supplies redistribution according to the necessities of the moment. Other activities like construction are just starting to acknowledge the

advantages of this type of tools driven by government policies aiming to the improvement of energy efficiency and resources management as well as the digitalization of all the stages previous to the construction projects which has created an increasingly amount of digital data that can meet the definition of BD. Therefore, this activity is subject to the benefits and both the challenges and opportunities that BD provides.

In the specific case of sustainability in the construction industry, all the improvement and the progress in its adoption obtained until today is closely related to government policy implementation process that has been going through the policy-making cycle over and over and adjusting to facilitate its adoption. The benefits that the adoption of BD can provide to the process of creating, implementing and succeeding in the achievement of policies translate in terms of time saving and accuracy of retrofit, which will allow in a general aspect a more efficient policy-making cycle and therefore improving the implementation and adoption of policies in all areas of human development including those focused in the adoption of sustainable practices in the construction industry and thus reducing the negative impact of this activity towards the environment. Also, it can be translated to the development of new cost and time saving practices that help to increase the attractiveness of sustainable trends for the construction industry and thus facilitate the adoption of sustainability as an intrinsic quality of future construction and human development projects.

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